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Evaluation of Novel Soybean Genotypes for Yield, Yield components, Seed Quality and Resistance to Cotton Leafworm

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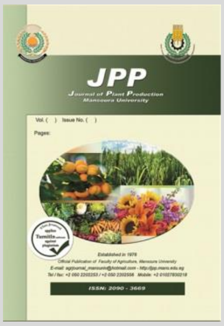

ABSTRACT

The current study was carried out at the experimental farm of Sakha Agricultural Research Station during 2020 and 2021 seasons. Sixteen soybean promising lines were evaluated for yield, yield components, seed quality and resistance to the cotton leafworm. H6L148, H5L41, H6L146 genotypes and Crawford cultivar were the earliest maturing ones and H1L4, H6L146, and H3L129 were the highest pod producing (125 -137 pods/plant). The highest seed yields were obtained from H3L129, H5L26, H5L137, H6L159 and H6L48 , while the lowest yields were those of H1L4, H4L130 genotype and Crawford cultivar. Oil percentages ranged between 21.70 and 26.43%, with the genotypes H5L137 and H4L130 having the highest values, while seeds of Giza 111 and Crawford harboured the lowest levels. Seeds of H3L4, H1L4 and Giza 111 had the highest protein percentage, while the lowest percentages were detected in seeds of H7L165, H6L48 and Crawford. The average larval populations of cotton leafworm were low 30 days after sowing (DAS), increased progressively to be highest 60 and 75 DAS. Depending on defoliated leaflet areas, the genotypes, H3 L129, H6 L48 and Giza111 were categorized as highly resistant to cotton leafworm, while H3 L120, H4L130, H3L4 genotypes and Crawford variety were categorized as susceptible. From the current study, it could be concluded that the soybean promising lines, H5 L137, H5L26 and H6 L159 are superior in seed yield, and seed oil and protein contents, and could be good candidates for promotion in soybean breeding program.

***Keywords**:* Soyabean Genotypes, Seed Yield, Seed Quality, Cotton Leafworm Infestation

INTRODUCTION

Soybean (*Glycine max* L.) is an annual legume crop, grown in variable climates from northern America to southern Asia, and used for a variety of purposes, in industrial operations, nourishment and fodder. As soybean seeds are rich in proteins (38-42%) and oils (18-22%), almost, 70% of the crop is used for feeding livestock and poultry (El-Khayat *et al*., 2019). In addition, soybean seeds contain 18-22% of unsaturated cholesterol-free oil. Worldwide, about 30% of vegetable oils are extracted from soybean seeds (USDA, 2021).

The major soybean producing countries are Brazil, United States, Argentina, China and India. However, the cultivated area in Egypt is limited, because of high competition of other summer crops, as soybean has occupied only about 150,000 feddans (1 fed = .042 ha) in 2023 (Anonymous, 2023). However, the local requirements from soybean products (seeds, oil and meal) are increasing yearly, which is covered through importation to feed the rapidly developing livestock and to cover the sharp decline in edible oils. Therefore, soybean specialists are doing their best to reduce the vast gap between production and consumption, through developing high-yielding genotypes with sustainable productivity even with biotic and abiotic stresses (El-Hamidi *et al*., 2020).

One of the major stresses that negatively affects the local soybean production is the cotton leaf worm, *Spodoptera littoralis* (Serag *et al*., 2019). This insect pest migrates from neighboring fields particularly cotton, and attacks voraciously the young plants feeding on plant leaflets, and may completely defoliate the plants (El-Khayat *et al*., 2019). In a previous assessment, Dubhbale *et al.* (2017) estimated losses in soybean yield due to cotton leafworms by 68% in the uncontrolled areas compared to those controlled by the insecticide cyhalothrin. Several species of cotton leafworms have been surveyed attacking soybean plants at different growth stages, reducing leaf areas (Serag *et al*., 2019) and feeding on flowers and pods (Silva *et al*. 2014, and Boica Junior *et al*. 2015). On all crops and with all insect pests, misuse of pesticides has resulted in several problems, such as environmental pollution, developing insect resistance and impairing human being health (Sherif *et al*. 2008). Accordingly, the integrated pest management (IPM) strategy should be applied to enhance sustainable agriculture in agroecosystems (Sherif *et al.* 2001). The most important element of IPM is developing genotypes resistant to the major insect pest of soybean; cotton leaf worm, *S. littoralis*. Host plant resistance is the key factor of IPM strategy, as it keeps healthy environment, without additional expenses, and is highly compatible with the other elements of IPM (Seifi *et al* 2013).

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The objectives of the current study were to evaluate the yield potential of 14 soybean promising lines as well as their reactions to the infestation with cotton leafworm *Spodoptera littoralis* comparing with two commercial check cultivars under the prevailing weather conditions throughout soybean growing season.

MATERIALS AND METHODS

1. Experimental site

The present study was conducted at the experimental farm of Sakha Agricultural Research Station, during 2020 and 2021 seasons. The soil is clayey texture, and the preceding crop was wheat.

2. Land preparation

The experimental area was tilled three times, with incorporation of calcium super phosphate (15.5% P_2O_5), just before the last tillage at the rate of 150 Kg/fed.

3. Plant materials

Sixteen soybean genotypes (14 promising lines and two commercial cultivars, Table 1) ,obtained from "Food Legume Crops Research Department, Field Crops Research Institute, ARC, Egypt.", were evaluated for yield and yield attributes, as well as for the reaction to *Spodoptera littoralis* Boised infestation.

Table 1. Pedigree and origin of the studied soybean genotypes, during 2020 and 2021 seasons

Genotype	Pedigree	Origin	Genotype	Pedigree	Origin
H1 L4	H20L3X Gasoy 17	Egypt	H6 L148	Toano X Nena	Egypt
H3 L119	H127X DR101	Egypt	H6 L159	Toano X Nena	Egypt
H3 L120	H127X DR101	Egypt	H7 L165	H127 X H155	Egypt
H3 L129	H127X DR101	Egypt	H3 L4	H127X DR101	Egypt
H4 L130	DR101X Lamar	Egypt	H5 L41	Giza 111X DR101	Egypt
H5 L26	Giza 111X DR101	Egypt	H6 L48	Toano X Nena	Egypt
H5 L137	Giza 111X DR101	Egypt	Giza111	Clawford X Celest	Egypt
H6 L146	Toano X Nena	Egypt	Crawford	Williams X Columbus	USA

4. Experimental design and sowing

Seeds of the16 genotypes were inoculated just at sowing with *Bradyrhizobium japonicum* (a mixture of several active bacterial strains), dissolved in water with some sugar. The inoculum was obtained from Agricultural Microbiology Research Department, Soil, Water and Environment Institute, ARC, Egypt.

The sixteen genotypes were sown in a randomized complete block design (RCBD), with three replicates, on May 19th in 2020, and on May 5th in 2021 season. The experimental plot comprised five ridges (3.5 m long each), 60 cm apart, and sowing took place in hills with 20 cm spacings. About four seeds were sown in each hill on both sides of the ridge, and later, the seedlings were thinned into two plants per hill. Mineral nitrogen fertilizer was applied at a rate of 15 kg N per feddan as ammonium nitrate (33.5%N) just before the first irrigation after sowing. In addition, potassium sulphate (K2O) was applied at a rate of 50 kg/fed before the second irrigation. Recommended agricultural practices were applied till harvest, but without any pesticide applications.

5. Data recorded

Soybean growth traits, yield and yield components

Number of days to 50% flowering and days to 75% maturity were recorded fpr each genotype.

At harvest, 10 guarded soybean plants were randomly taken from each plot to estimate: plant height (cm), number of branches/plant, number of pods/plant, and 100-seed weight (g). In addition, the seed yield (kg) of the three middle ridges in each experimental plot was measured, and then converted into tones per feddan.

Seed chemical composition

Seed chemical composition of the 16 soybean promising lines was assessed during 2020 and 2021 seasons at Seed Technology Department, Sakha Agricultural Research Station. To assess oil content, ten grams of crushed seeds were used to extract the seed oil, using petroleum ether for 6h in Soxhlet system according to the AOCS method (A.O.A.C., 1993). To evaluate protein content, a certain weight of the finely crushed seeds (about 0.1g) was digested using micro-Kjeldahl apparatus with 98% H_2SO_4 and 30% H_2O_2. The crude protein was calculated by multiplying the total nitrogen by 6.25, according to Sanful and Darko (2010). Ash and crude fiber contents were determined according to A.O.A.C. (1990). Carbohydrate contents were calculated by the difference as follows: [100-(oil + protein + ash+ crude fiber +moisture%)]

Cotton leafworm

Leaflet infestation percentage

About one month after sowing up to late August, in 2020 and 2021 seasons, weekly samples of 60 soybean leaflets (20 plants, with 3 leaflets each, from upper, middle and lower levels of each plant) were piced up from each plot. The leaflets were examined and sorted into uninfested and infested with cotton leafworm, to calculate percentage of cotton leafworm infestation

Leaflet defoliated area%

From each plot, 30 insect infested leaflets (10 plants x 3 leaflets) were selested, examined and classified into six scores as follows:

Score (1) = few number of pin holes to 10 % leaflet defoliated area

Score (2) = >10% up to 20 % leaflet defoliated area

Score (3) = > 20 % up to 30 % leaflet defoliated area

Score (4) = > 30 % up to 40 % leaflet defoliated area

Score (5) = > 40% up to 50 % leaflet defoliated area

Score (6) = > 50% leaflet defoliated area

$$\text{Leaflet defoliated area(\%)} = \frac{\text{Score 1} \times \text{No. of leaflet} + \text{Score 2} \times \text{No. of leaflet} + \ldots\ldots}{\text{Total No. of infested leaflets}}$$

Susceptibility categories of soybean promising lines to cotton leafworm infestation

For each soybean genotype, average percentage of leaflet defoliated area was calculated. In addition, overall average ($\bar{x}$) and standard deviation of the 16 soybean genotypes was calculated. Category of genotype susceptibility to cotton leafworm was assessed according to formulae of Chiang and Talekar (1980), as shown in Table 2.

Meteorological records

Records of temperature and relative humidity (maximum and minimum values) were obtained from Meteorological Research Station, located at Rice Research and Training Center, Sakha Agricultural Research Station, throughout the period from the beginning of June up to the end of August. Records of temperature and relative humidity were calculated as the averages of seven days preceding the assessment of cotton leafworm damage in the leaflets.

Correlation coefficient values between cotton leafworm larval population and each of temperature and relative humidity were computed.

Table 2. Categories of soybean susceptibility to *Spodoptera littoralis*

Category of susceptibility	Leaflet defoliation % From	To
HS: Highly susceptible	More than x̄ +2SD	
S: Susceptible	x̄	x̄+2SD
LR: Low resistant	x̄	x̄-1sd
MR: Moderately resistant	x̄-2SD	x̄-1SD
HR: Highly resistant	Less than x̄-2SD	

Statistical analysis

Data were analyzed with the appropriate method of Gomez and Gomez (1984) using MSTAT-C Software, at 5% degree of probability. Duncan (1955) multiple range test was used to compare the treatment means. Simple correlation coefficients were calculated between cotton leafworm larval populations and some meteorological records. Also, standard errors and standard deviations were calculated and were accompanied with the averages of cotton leafworm infestations occurring at differnt soybean growth stages.

RESULTS AND DISCUSSION

Results

1. Soybean growth traits

Plant height (cm)

In 2020 and 2021 seasons, the tallest plants (Table 3) were measured in H3L129, H5L26, , H6L159 and Giza 111 genotypes (ranging between 114.33 and 121.33 cm). On the other hand, the shortest plants were recorded in H3L120, H4L130 and H7L165 genotypes (ranging between 70.33 and 75.66 cm) in the first and second seasons, successively. The differences among the evaluated genotypes in plant heights were highly significant.

Days to 50% flowering

The earliest flowering (days to 50% flowering) soybean genotypes were H6L159 (37.33 & 38.00 days) and H3L120 (38.67& 39.33 days) in the two successive seasons, respectively. However, the latest flowering ones were H1L4 (47.00 &42.33 days), H5L26 (43.33 &44.33) and H7L165 (44.00 &46.00 days), in 2020 and 2021 seasons, respectively. Averages of flowering time varied among the evaluated genotypes with highly significant differences.

Table 3. Growth traits of evaluated soybean genotypes, during 2020 and 2021 seasons

Genotype	Plant height (cm)		Days to 50% flowering		Days to maturity	
	2020	2021	2020	2021	2020	2021
H1 L4	82.00f	81.00c	47.00a	42.33a-e	130.67c	127.66d-g
H3 L119	111.67b-e	110.00b	40.67de	40.33c-g	137.67a	129.33c-f
H3 L120	70.33g	71.00c	38.67ef	39.33d-g	139.33a	134.00ab
H3 L129	119.00bc	118.00b	38.67ef	41.33b-g	137.00ab	132.33bc
H4 L130	72.00g	73.33c	44.00b	41.67b-f	135.00b	136.00a
H5 L26	121.33b	118.33b	43.33bc	44.33ab	138.67a	136.33a
H5 L137	109.33cde	112.67b	39.33def	38.67efg	127.00de	126.00fg
H6 L146	108.67de	110.67b	41.33cd	38.67efg	127.00de	125.33g
H6 L148	111.67b-e	115.00b	38.67ef	42.67a-d	125.00ef	128.33g
H6 L159	119.00bc	114.33b	37.33f	38.00fg	128.67cd	128.00d-g
H7 L165	73.67fg	75.66c	44.00b	46.00a	130.667c	130.00d-g
H3 L4	79.67fg	78.00c	40.67de	43.33abc	129.67c	131.00cde
H5 L41	103.33a	105.67a	38.67ef	40.33c-g	125.00ef	127.00bcd
H6 L48	108.67de	110.67b	38.67ef	40.00c-g	126.00ef	128.33efg
Giza111	116.67bcd	117.00b	40.67de	38.66efg	127.00de	128.00d-g
Crawford	106.33e	111.00b	39.33def	37.67g	124.33f	126.00d-g
F test	**	**	**	**	**	**

Means followed by the same letter are not significantly different at 0.05 probability

Days to maturity

Genotypes, H6L148, H5L41, H6L146 and Crawford were the earliest maturing ones (from 125.00 to 128.33 days) while the latest maturing ones were H3L120, H4L130 and H5L26 (from 134.00 to 139.33 days).

2. Soybean yield and yield components

Number of branches/plant

In 2020 season (Table 4), the highest branching genotypes were H6L159 and H7L165, each with 6.00 branches/plant, surpassing the two commercial varieties; Giza111(5.67) and Crawford (3.33 branches/plant). Also, in 2021 season, both H5L26 and H7L165, each produced 5.67 branches/plant, which is superior over both commercial varieties. Highly significant differences were found among the screened promising lines in such trait.

Number of pods/plant

The highest pod producing genotypes were H1L4 (145 &127), H6L146 (135 &125) and H3L129(137 &132 pods/plant) in 2020 and 2021 seasons, respectively. Giza 111, the resistant check to cotton leafworm, produced a moderate number of pods (127 &108), while Crawford, the susceptible check, produced low numbers of pods (110 &105 in the first and second seasons, respectively) (Table 4). Statistical analysis revealed highly significant differences among the screened genotypes in such trait.

100-seed weight (g)

The 16 genotypes exhibited highly significant differences among each other, in both seasons, concerning 100- seed weight.

Table 4. Yield and yield components of evaluated soybean genotypes, during 2020 and 2021 seas The soybean genotypes H4L130, H7L165 and H1L4 produced the heaviest seeds (19.67& 20.00, 19.00& 19.33 and 19.33 & 19.00 g/100 seeds) in the first and second seasons, respectively (Table4). Conversely, the least values of 100-seed weight were those of H5L137 and H6L146 with weights ranging between 14.00 and 15.00 g/100 seeds in both seasons. The commercial cultivar, Crawford had, also, low seed weights; 14.67 & 15.00 g/100 seeds in both seasons, respectively.

Table 4. Yield and yield components of evaluated soybean genotypes, during 2020 and 2021 seasons

Genotype	No.of branches/plant		No.of. pods/plant		100- seed weight (g)		Yield (kg/feddan)	
	2020	2021	2020	2021	2020	2021	S1	S2
H1 L4	3.67de	3.00e	145a	127c	19.33ab	19.00b	1600.50de	1582.00cd
H3 L119	5.67ab	5.00abc	127g	125d	16.33ef	16.33d	1816.40a-d	1606.00bcd
H3 L120	5.00abc	5.00abc	124k	118g	17.33d	17.33c	1700.30cde	1582.67cd
H3 L129	5.00abc	5.33ab	137b	132a	14.67hi	14.67fg	2175.11a	1980.00a
H4 L130	3.00e	3.00e	101n	89m	19.67 a	20.00a	1366.67ef	1176.00e
H5 L26	5.33ab	5.67abc	136c	120f	16.67de	16.67cd	2183.50a	1807.34abc
H5 L137	3.67de	4.33bcd	126i	109i	14.00i	14.00g	2108.20ab	1940.77a
H6 L146	4.00cde	4.00cde	135d	125d	14.67i	15.00fg	1870.30a-d	1621.00bcd
H6 L148	4.67bcd	3.33e	130e	122e	16.00fg	15.60fg	1916.60a-d	1810.00abc
H6 L159	6.00a	3.67de	128f	102k	15.00hi	15.00g	2100.80ab	1896.00ab
H7 L165	6.00a	5.67a	130e	115h	19.00b	19.33ab	1940.50a-d	1750.00a-d
H3 L4	4.00cde	4.00cde	128f	130b	18.33c	18.67b	1666.42de	1562.00cd
H5 L41	4.33cd	3.00e	120l	100l	15.33gh	15.33ef	1783.40bcd	1459.00d
H6 L48	5.33ab	4.00cde	125j	105j	15.333gh	15.00fg	2033.50abc	1795.00abc
Giza111	5.67ab	3.00e	127h	108i	16.67def	16.00de	1833.20a-d	1645.00 bcd
Crawford	3.33e	4.00cde	110m	105j	14.673hi	15.00fg	1200.77f	1100.00e
F test	**	**		**	**	**	**	**

Means followed by the same letter are not significantly different at 0.05 probability

Seed yield/feddan (kg)

The highest soybean seed yields were obtained from H3L129, H5L26, H5L137, H6L159 and H6L48 genotypes with yields ranging between 2033.50 and 2183.50 kg/fed. in the first season, and between 1795.00 and 1980.00 kg/fed. in the second one. Giza111 yielded 1833.20 and 1645.00 kg/fed, in the first and second seasons, respectively. Contrarily, the lowest yields (1100.00 – 1366.67 kg/fed), in both seasons, were those of H4L130 genotype and Crawford cultivar. The remaining genotypes produced moderate yields.

3- Chemical composition of soybean seeds

All considered chemical compositions of soybean seeds varied significantly among the evaluated genotypes (Table 5). These characteristics were percentages of oil, protein, ash, fiber, and carbohydrates.

Oil percentage

Average oil percentages ranged between 21.70 and 26.43%, with significant differences among the 16 evaluated genotypes. Seeds of both H5L137 and H4L130 had the highest oil values; 26.43 and 25.64%, respectively. However, seeds of Giza 111 and Crawford contained the lowest oil percentages; 22.75 and 21.70 %, respectively.

Protein percentage

Protein percentages were highest in H3L4, H1L4 and Giza 111 with arange of 36.77 -37.05. However, the lowest protein percentages were detected in seeds of H7L165, H6L48 genotypes and Crawford cultivar with values ranging between 33.10 - 33.84%,

Table 5. Percentages of seed chemical components of evaluated soybean genotypesduring 2020 and 2021 seasons

Genotype	Oil%			Protein%			Ash%			Crude fiber%			Carbohydrate%		
	2020	2021	Av	2020	2021	Av	2020	2021	Av	2020	2021	Av	2020	2021	Av
H1L4	22.58e	24.5 b	23.54	36.13ab	37.8 a	36.97	4.27b	3.8d	4.04	6.7b	7.2a	6.95	20.32b	21.1b	20.74
H3L119	21.89f	23.8 c	22.85	34.83c	35.2b	35.02	4.43b	4.0c	4.22	6.87b	6.1b	6.49	21.97a	22.2a	22.09
H3L120	23.81a	25.0ab	24.41	35.57b	36.7ab	36.14	4.73a	4.4c	4.57	7.2a	6.3b	6.75	19.69c	20.1c	19.90
H3L129	22.21e	23.4c	22.81	35b	35.9b	35.45	4.87a	4.2c	4.54	7.77a	7.1a	7.44	20.16b	20.5c	20.33
H4L130	24.47ab	26.8 a	25.64	35.5b	36.8ab	35.15	5.33a	6.2a	5.77	6.57b	7.2a	6.89	19.26	19.7d	19.48
H5L26	23.55c	25.9 a	24.73	34.97c	36.2b	35.59	5.43a	6.0a	5.72	657b	7.2a	6.89	20.49b	20.9b	20.70
H5L137	25.05a	27.8 a	26.43	32.8d	33.5d	35.15	4.33b	4.9c	4.62	6.7b	7.1a	6.89	21.1a	21.6b	21.35
H6L145	24.08ab	27.1a	25.59	33.17c	34.6c	33.89	4.6ab	5.1b	4.85	6.27c	6.6ab	6.44	21.88a	22.8a	22.34
H6L148	23.77c	24.5b	24.14	35.13b	36.4b	35.77	5.07a	5.6ab	5.34	6.67b	6.1b	6.39	19.36c	20.1d	19.73
H6L159	23.62	24.4b	24.01	34c	35.7b	34.85	4.53ab	5.0b	5.77	5c	5.2c	5.10	22.85a	23.1a	22.98
H7L165	23.91b	24.7b	24.31	33.07c	34.6c	33.84	4.8ab	5.2b	5.00	6.03b	5.3c	5.67	22.5a	23.0a	22.75
H3L4	23.73c	25.6	24.67	36.13ab	37.4a	36.77	4.5b	5.1b	4.80	7.43a	7.2a	7.32	19.2c	19.3d	19.25
H5L41	23.47c	25.2ab	24.34	35.57b	36.3b	35.94	5.03a	5.3b	5.17	7.7a	7.5a	7.60	19.23c	19.5d	19.37
H6L48	24.14b	26.2a	25.17	33c	33.7d	33.35	4.43b	5.0b	4.72	6.47b	6.3b	6.39	22.26a	23.0a	22.63
Giza 111	21.9f	23.6c	22.75	36.3ab	37.8a	37.05	4.9a	5.1b	5.00	6.5b	6.2b	6.35	21.7a	22.1a	21.90
Crawford	21f	22.4d	21.70	39.3a	38.9a	33.10	3.23c	4.1c	3.67	6.1b	5.5c	5.80	21.1a	21.4b	21.35
F test	**	**		**	**		**	**		**	**		**	**	

Means followed by the same letter are not significantly different at 0.05 probability

ash and Crude fiber percentage

Significant differences were found among the 16 evaluated soybean genotypes concerning ash content in the seeds. The highest values were recorded in H4L130, H5L26 and H6L159 genotypes (Table5). Genotypes H3L129, H3L4 and H5L41 were significantly superior over the other genotypes in fiber content, while H6L159 and H7L165 and Crawford harbored the lowest fiber levels.

carbohydrate percentage

As for carbohydrates, the genotypes, H6L145, H6L159, H3L119, and H6L48 had the highest levels of carbohydrates (22.09-22.98%), as almost close to Giza 111. The lowest carbohydrate levels were assessed in seeds of H3L120, H4L130, H3L4 and H5L41 (19.25-19.90%).

In a conclusion, screening of the 16 soybean genotypes for two seasons revealed that H4L130 and H5L137are good candidates for promotion for high levels of seed oil. Also, H3L4, H1L4 and Giza 111 could be promoted for breeding for high seed protein content.

4.Susceptibility of soybean genotypes to cotton leafworm, *Spodoptera littoralis* infestation and associated yield

Popuation fluctuation of *Spodoptera littoralis* larvae throughout soybean season

Data In Table (6) presnt the laraval populations per 10 soybean plants 30, 45, 60 and 75 days after sowing (DAS), over the 16 evaluated genotypes. In 2020 season, the average larval population was low (6.48/10 plants) 30 DAS, increased to 13.87, 24.29 and 38.31 larvae/10 plants 45, 60 and 75 DAS, respectively. Laraval populations took a similar trend in 2021 season with the corresponding values of 8.77, 14.21, 27.63, and 32.81 larvae/ 10 plants, respectively. Taken the geotypes into cnsideration in both seasons of study, the lowest infested genotypes were H5L41, H6L48 and Giza111, while the highest larval popualtions were recorded on leaflets of H3L120, H4L130, H5 L26 , H3 L4 and Crawford.

Correlation coefficient values between density of *Spodoptera littoralis* larvae in soybean fields and weather factors

Over the 16 soybean genotypes, correlations between weekly numbers of *Spodoptera littoralis* larvae and some weather factors were computed (Table 7).

Table 6. Popuation fluctuation of *Spodoptera littoralis* larvae throughout soybean seaseon

Genotype	No. of *Spodoptera littoralis* larvae/ 10 soybean plants									
	2020 Season					2020 Season				
	Days after sowing				Av.	Days after sowing				Av.
	30	45	60	75		30	45	60	75	
H1 L4	3.67	10.33	25.00	40.67	19.92	4.67	8.33	26.00	32.00	17.75
H3 L119	2.33	8.67	20.33	26.67	14.50	5.00	6.67	30.33	20.33	15.58
H3 L120	8.00	15.67	50.00	39.33	28.25	7.33	12.67	30.00	50.00	25.00
H3 L129	6.00	13.83	18.00	23.67	15.25	10.00	10.33	31.67	20.00	18.00
H4 L130	7.00	20.33	33.33	60.67	30.33	10.00	22.33	45.67	65.00	35.75
H5 L26	8.33	20.67	30.33	62.00	30.33	7.33	16.67	42.00	51.00	29.25
H5 L137	4.33	10.00	15.67	30.00	15.00	16.67	15.00	15.67	22.33	17.42
H6 L146	6.00	11.67	20.67	35.00	18.34	13.00	12.67	20.67	31.00	19.34
H6 L148	5.67	10.00	20.33	40.67	19.17	9.00	20.00	30.33	20.67	20.00
H6 L159	6.00	11.33	19.33	42.00	19.67	11.00	15.67	22.33	25.00	18.50
H7 L165	3.00	12.67	20.00	41.00	19.17	6.00	12.33	25.00	21.67	16.25
H3 L4	10.67	15.33	30.00	45.33	25.33	11.00	18.67	41.33	52.00	30.75
H5 L41	2.00	5.67	15.00	22.33	11.25	3.00	7.67	12.00	18.67	10.35
H6 L48	8.33	9.00	18.00	25.67	15.25	6.67	11.67	19.33	20.00	14.42
Giza111	7.00	6.67	10.00	16.00	9.92	3.00	7.67	9.00	15.00	8.67
Crawford	15.33	40.00	42.67	62.00	40.00	16.67	29.00	40.67	60.33	36.67
Average	6.48	13.87	24.29	38.31		8.77	14.21	27.63	32.81	
±SE	± 0.84	± 2.04	± 2.65	± 3.56		±1.06	±1.52	±2.75	±4.02	
SD	3.36	8.17	10.59	14.25		4.24	6.08	11.00	16.80	

Table 7. Correlation coefficient values between *Spodoptera littoralis* Larval populationin soybean fields and some weather parameters, during 2020 and 2021 seasons

Year	Item	"r" value	"p" value	Significance
2020	*S. littoralis* X Max. Temp	0.6150	0.0575	**
	S.littoralis X Min. Temp	0.5275	0.1171	*
	S.littoralis X Max. RH%	0.4738	0.1666	*
	S. littoralis X Min. RH %	0.4744	0.1660	*
2021	*S. littoralis*X Max. Temp	0.9126	0.0006	**
	S. littoralis X Min. Temp	0.8469	0.0040	**
	S. littoralis X Max. RH %	0.8097	0.0082	**
	S. littoralis X Min. RH %	-.3909	0.2982	ns

In both seasons, the larval population positive significantly correlated with maximum and minimum temperatures and relative humidity, except for minimum relative humidity that had insignificant negative correlation with the insect pest in 2021 season.

Reaction of soybean genotypes to *Spodoptera littoralis*

Data presented in Table (8) exhibit the reactions of the 16 evaluated geotypes to infestation by the cotton leafworm, *Spodoptera littoralis*.

In 2020 season, the genotypes, H3 L129, H6 L48 and Giza111 were categorized as highly resistant (HR) to cotton leafworm, as they had the least defoliated leaflet areas (8.07 – 8.60 %), while H3 L120, H4L130, H3L4 genotypes and Crawford variety were categorized as susceptible (S) with the highest defoliated leaflet areas (29.05 - 30.34 %). In 2021 season, almost, similar results were obtained. Both H3L129 and Giza111 performed as highly resistant, while H1 L4, H4 L130, H3 L4 genotypes and Crawford exhibited susceptibility to the cotton leafworm.

On the other hand, soybean yields were higher in genotypes that had lower *Spodoptera littoralis* infestations compared to the lower yields in soybean genotpes that suffered higher insect infeastation

In the current study, the soybean genotypes identified with low cotton leafworm infestation could be utilized in soybean breeding programs to develop novel soybean varieties resistant to the cotton leaf worm, as a key insect pest of soybean plants.

Table 8. Susceptibility of soybean genotypes to cotton leafworm, *Spodoptera littoralis* infestation and associated Yield

Genotype	2020 Season				2021Season			
	Infested leaflets %	Leaflet defoliated area %	Reaction	Yield Kg/fed	Infested leaflets %	Leaflet defoliated area %	Reaction	Yield Kg/fed
H1 L4	35.17	20.16	LR	1600.50de	35.09	30.13	S	1582.00 cd
H3 L119	20.18	9.50	MR	1816.40a-d	25.00	15.11	LR	1606.00bcd
H3 L120	37.88	29.72	S	1700.30cde	30.00	28.11	LR	1582.67cd
H3 L129	22.18	8.07	HR	2175.11a	17.67	9.00	HR	1980.12a
H4 L130	36.17	29.92	S	1366.67ef	35.19	33.26	S	1176.00e
H5 L26	33.55	24.31	LR	2183.5a	24.67	15.66	LR	1807.34abc
H5 L137	28.17	22.20	LR	2108.20ab	30.33	20.17	LR	1940.77a
H6 L146	29.15	24.43	LR	1870.30a-d	31.19	23.00	LR	1621.00bcd
H6 L148	33.07	22.36	LR	1916.60a-d	34.33	25.16	LR	1810.33abc
H6 L159	31.99	22.99	LR	2100.80ab	26.67	19.36	LR	1896.00ab
H7 L165	28.55	21.80	LR	1940.50a-d	35.33	27.44	LR	1750.11a-d
H3 L4	35.62	29.05	S	1666.42de	35.67	31.09	S	1562.00cd
H5 L41	16.07	9.63	MR	1783.40bcd	16.33	9.48	MR	1459.01d
H6 L48	12.19	8.31	HR	2033.50abc	19.33	9.60	MR	1795.00abc
Giza111	10.10	8.60	HR	1833.20a-d	12.33	8.90	HR	1645.05bcd
Crawford	42.33	30.34	S	1200.77f	45.64	32.16	S	1100.00e
F test	**	**		**	**	**		**

S: Susceptible LR: Low Resistant MR: Moderately Resistant HR: Highly Resistant
Means followed by the same letter are not significantly different at 0.05 probability

Discussion

Soybean (*Glycine max* L.) is a vital crop worldwide, with highly nutritious proteins and oils. Because it is used in several purposes; in industrial operations, and in feeding livestock and poultry, it has become an appropriate crop in sustainable agriculture (Suyal *et al*. 2018). In Egypt, there is a very big gap between supplies of edible oils and consumption, therefore, all researchers interested in soybean production, do great efforts for maximizing crop productivity. This could be achieved through developing high yielding promising lines with high seed oil and protien contents, as well as minimizing losses due to the most destructive insect pest; cotton leafworm, *Spodoptera littoralis* Boisd (EL-Hamid*et al*. 2020).

Growth traits

Both growth and yield traits were emphasized by Haspari *et al*. (2021) as selection criteria in soybean breeding programs for developing high yielding genotypes.

In our study, the heights of the screened genotypes significantly varied from 70.33 to 121.33 cm. Several authors (Hakim 2011, Ghanbari *et al*. 2016, Krishnawati and Aide 2016 and Finoto*et al*. 2021) found that taller soybean plants significantly yielded higher than shorter ones.

In the current investigatiin, H6L148, H5L41, H6L146 genotypes and Crawford cultivar were the earliest maturing ones (from 125.00 to 128.33 days), while the latest ones were H3L120, H4L130 and H5L26 (from 134.00 to 139.33 days). Some authors (e.g. Minmin *et al.*2019) preferred the late maturing varieties as they yielded higher than the early ones, under the circumstances of their trials. Conversely, some othors (e.g. Naidu *et al*. 2016) claim that short duration soybean genotypes are more desirable, as they are harvested earlier allowing the following crops to be grown at the proper times.

Yield and yield components

Number of branches per plant is one of the important components contributing to soybean yield (Ghanbari *et al*. 2018). The evaluation of the current 16 soybean genotypes revealed significant differences, as H6L159 and H7L165 produced the highest number of branches, surpassing the two commercial varieties; Giza 111 and Crawford. Both Minmin *et al*. (2020) and Haspari *et al*. (2021) strongly recommended selecting for high branching soybean genotypes through developing new high yielding varieties. In addition, Minmin *et al*. (2019) emphasized the key role of number of soybean pods as well as 100-seed weight in the formation of final yield. In the current study, the highest pod producing genotypes were H1L4, H6L146 and H3L129 Hoewever, Giza 111, the resistant check to cotton leafworm, produced a moderate number of pods, but Crawford, the susceptible check, produced low numbers of pods.

Seed quality

Producing high soybean seed quality is an important approach, as it contributes 20-25% to crop productivity (Pal *et al.*2016). Ebone *et al.* (2020) clarified that producing soybean seeds of high quality is crucial to achieve a good germination, healthy seedlings and vigor plants to realize satisfactory crop production.

In the current study, oil percentages in the 16 screened genotypes ranged between 21.70 and 26.43%, which is a good level compared to Liu (1997) who considered that soybean genotypes, estimated in his study with 20% oil, occupies the best rank, among all oil seed plants, next to peanut seeds that contain 48% oil. Furthermore, our assessments showed that the 16 genotypes harbored higher levels of oil than those obtained by Sharma *et al.* (2014) who screened 28 soybean genotypes with 14.0-18.7% oil content.

The current investigation revealed that the seeds of evaluated genotypes had 33.10 - 37.05% protein which is close to the assessments of Sharma *et al.* (2014). In addition to the importance of soybean seeds, with high contents of oils and proteins, Messina*et al*. (1994) focused the roles of micro-components in soybean seeds (e.g. flavones) that act as an important compound against human cancers and some other diseases.

It is well known that the contents of soybean seeds are mainly affected by the genetic structure of a genotypes, but environmental conditions contribute the crop productions. In such concern, drought stress enhances seed contents of protein, but reduces the levels of oils, conversely, high temperatures, during pod filling, reduce proteins and increase oil levels (Sharma *et al.*2014). Bueno *et al.* (2018) studied the correlations among some chemical components of soybean seeds, indicating into significant positive correlations between seed oil content and each of sucrose and raffinose- stachyose, but the correlation was significantly negative in case of seed protein content.

The results obtained in the current research are important to be utilized, by soybean breeders, to produce new genotypes with improved seed protein and oil. Soybean genotypes, having better growth traits and high assimilation rates, are mostly yielder than those of moderate or low growth characteristics (Minmin *et al* .2019).

On the basis of the aforementioned results and discussion, wide diversified soybean genotypes is of a great importance, that should be included in the breeding programs to develop genotypes with high yields and tolerant to biotic and abiotic stresses. In this context, Kang (1998) and Waly (2021) concluded that widening the genetic base of soybean germplasm is crucial to mitigate stresses resulting from low- diversified genotypes. Accordingly, soybean varieties, more adaptable to stresses, should be promoted in breeding programs.

Cotton leafworm infestation in soybean genotypes

The cotton leaf worm, *Spodoptera littoralishas* has been confirmed to be a voracious insect pest on soybean, with great crop losses, if no control measures have been applied (Waly 2021, Kattab *et al*. 2022 and Abdel – Wahab and Naroz 2023). In addition to biotic stresses, soybean cultivars, subject to abiotic stresses, suffer from negative effects in quantity and quality (Suyal *et al* 2018).

In our study, the damage of cotton leaf worm was observed about three weeks post sowing, while Boica Junior *et al* (2015) detected the insect infestation in soybean fields just 15 days after sowing, with reducing leaf area and later feeding upon pods (Silva *et al*., 2014). Several authors (e.g Smith and Talekar2012 and Seifi*et al*., 2013) recommended using resistant varieties, as an important strategy, in controlling cotton leafworm. In the current study, the genotypes, H3 L129, H6 L48 and Giza111 were categorized as highly resistant to this insect pest, which is similar to the findings of El-Boraei *et al* (1992), El-Khayat *et al*. (2019) and Abdel –Wahab and Naroz (2023) who screened Giza 111 variety as resistant to cotton leafworm. Crawford variety was categorized as susceptible with the highest defoliated leaflet areas (30.34 - 32.16 %), which is in line with results of El-Boraei *et al* (1992) who assessed Giza 111 defloliation by about 45%.

Correlations between *Spodoptera littorallis* population and weather factors

Our results confirmed that the correlations between *Spodoptera littoralis* larval population and each of maximum and minimum temperature and relative humidity were either positively significant, or positively highly significant. The exception was in minimum relative minimum humidity that was insignificant in the first season (2021). Almost, the same trend was reported by Suyal *et al.*(2018) and El-Khayat *et al* (2019), recording positive correlation between the insect and temperature. Likewise our results, El-Khayat *et al*. (2019) found that the correlation between *Spodoptera littoralis* population and minimum relative humidity was insignificant.

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تقييم سلالات فول صويا جديدة للمحصول ومكوناته , وجودة البذور, والمقاومة لدودة ورق القطن

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الملخص

أجريت الدراسة الحالية في المزرعة البحثية لمحطة البحوث الزراعية بسخا خلال موسمي 2020 و2021. تم تقييم ستة عشر تركيبا وراثيًا لفول الصويا من حيث صفات النمو، والمحصول ومكوناته ، وجودة البذور , ودرجة المقاومة للإصابة بدودة ورق القطن .كانت السلالات المبشرة H6L148 و H5L41و H6L146والصنف كراوفورد هي الأبكر نضجا (من 125.00 إلى 128.33 يومًا) وكانت التراكيب الوراثيةH1L4 ، H6L146 ، و H3L129هي الأعلى إنتاجاً للقرون (125 -137 قرنا/نبات) .تم الحصول على أعلى إنتاجية من بذور فول الصويا من السلالاتH3L129 ، H5L26، H5L137، H6L159 وH6L48) تتراوح بين 1795.00و2183.50 1980.00 كجم/فدان (تراوحت متوسطات نسب الزيت فى البذور بين 21.70 و26.43%، وكانت أعلى القيم فى السلالتين H5L137 و ,H4L130كما احتوت بذور السلالاتين H3L4 و H1L4والصنف جيزة 111 على أعلى نسبة من البروتين.(% 37.05- 36.77) وبالنسبة لحساسية السلالات المختبرة للإصابة بدودة القطن ..كان متوسط عدد يرقات الحشرة منخفضاً بعد 30 يوماً من الزراعة، وسجل أعلى تعداد بعد 60 و75 يوماً من الزراعة.تم تصنيف السلالاتين H3L129 و H6L48 والصنف Giza111على أنها عالية المقاومة لدودة ورق القطن، حيث كانت بها أقل نسبة تأكل للوريقات ، في حين تم تصنيف السلالات H3 L120 و H4L130و H3L4والصنف كراوفورد على أنها حساسة وكانت بها أعلى نسبة تأكل للوريقات .خلصت الدراسة الحالية إلى أن السلالات H5 L137 :و H5L26و H6 L159كانت متفوقة في محصول البذور ومحتوى البذور من الزيت والبروتين. وعلى هذا يمكن الاستفادة من هذه السلالات الثلاثة المبشرة فى برامج تربية فول الصويا لإنتاج أصناف جديدة.